Meriam 3/1 – 3/5 : Particle Kinetics

Particles → Focus was on Translation (not rotation)

Newton's Second Law : $\Sigma \vec{F} = m\vec{a}$

only applicable in a

same thing
- non-accelerating reference frame
- Galilean reference frame
- Inertial reference frame

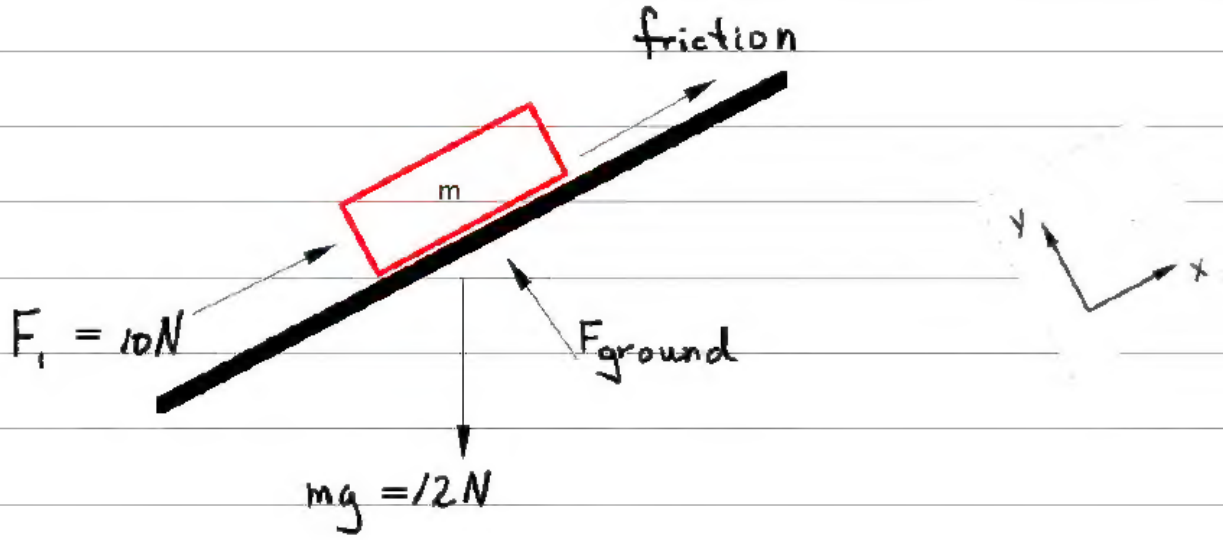
$\Sigma \vec{F} = m\vec{a}$ is a vector equation

→ we can decompose it into multiple scalar eqns:

$$\Sigma F_x = ma_x$$
$$\Sigma F_y = ma_y$$
$$\Sigma F_n = ma_n$$
$$\Sigma F_t = ma_t$$
$$\Sigma F_r = ma_r$$
$$\Sigma F_\theta = ma_\theta$$

Solution Method

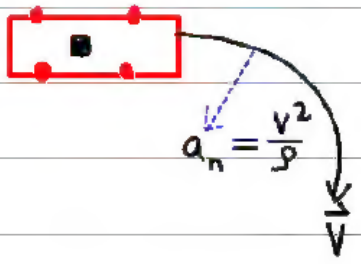
- Draw a free-body diagram
- Include a coordinate system
- Include all Real forces
  (no inertial or fictitious forces)
- Indicate directions of all forces (if known)
  If direction is unknown, assume it is +ve direction

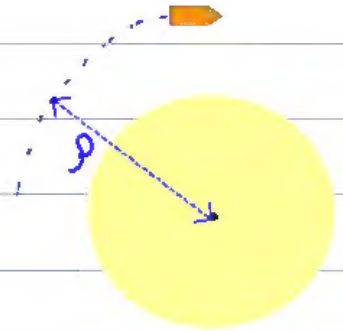


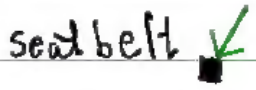
What are fictitious forces?
Where do they come from?
How do I recognize them?

Eg.

- Going around a sharp corner in a car
- Skateboarder in a truck
- Rocket in orbit around earth







FBD

FBD

FBD

Eg. Find speed for a stable circular orbit at an altitude of 1000 km.

$$a_n = v^2/\rho = F_n/m = \frac{G\, m_{earth}\, \cancel{m}}{r^2} \Big/ \cancel{m}, \quad \text{where } r = \rho$$

$$\frac{v^2}{(6371\,E3 + 1000\,E3)} = \frac{(6.67E-11)(6.0\,E24)}{(6371\,E3 + 1000\,E03)^2}$$

$$v^2 = 5.43\,E7 \rightarrow \boxed{v = 7368\ m/s}$$

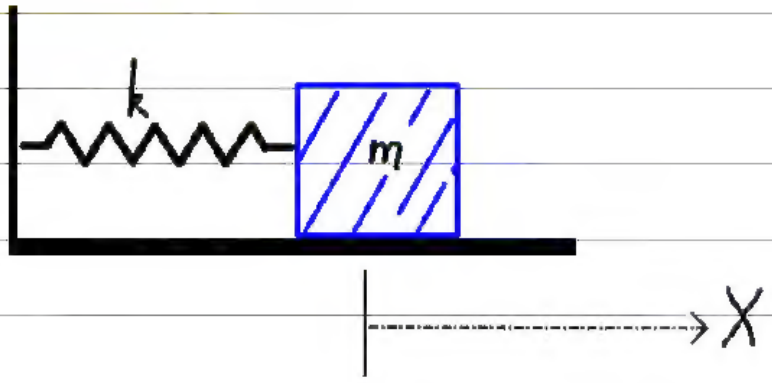
weight on the surface of the Earth:

$$\text{weight} = |\vec{F}_g| = \left(\frac{G M_e}{R_e^2}\right)^{g} (m)$$

$$\text{weight} = mg \quad , g = 9.81\ m/s^2$$

Do not confuse weight and mass !!

Spring Forces



Hooke's Law: $F = -kx$

Where

x = spring extension (+ve or −ve)

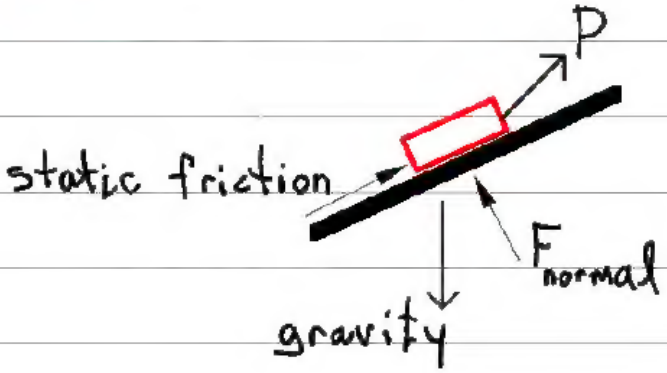
k = spring constant (N/m)

Friction — Two types

Read the Friction Handout !

1/ Static Friction

- No slippage between 2 contacting surfaces
- Static friction prevents slippage from starting



No slippage

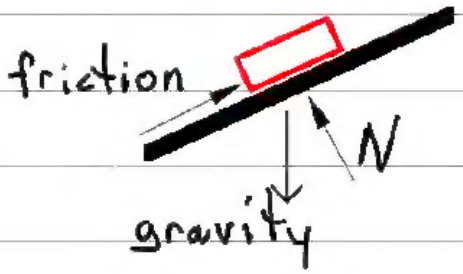
2/ Kinetic Friction

- Occurs between two sliding bodies
- Direction of kinetic friction tries to stop the slippage.

Equations for Friction Forces

1/ Static Friction:

$$|\text{Friction}_s| \leq \mu_s N$$



where N = force $\perp$ to boundary
i.e. N = force trying to squish 2 bodies together.

μ_s = coefficient of static friction (dimensionless)
(its value depends on surfaces of both objects)

Note: $|\text{Friction}_s| = \mu_s N$ only if slippage is about to occur!

Otherwise, solve for static friction force using
$\Sigma \vec{F} = m\vec{a} = 0$ if items are stationary

2/ Kinetic Friction

$$|\text{Friction}_k| = \mu_k N$$

where μ_k = coefficient of kinetic friction $< \mu_s$
Direction of force opposes slippage.

Summary

- $\sum \vec{F} = m\vec{a}$
  - vector equation
  - valid in all inertial refence frames & coord systems
  - use a free body diagram to solve

- Common Forces:

gravity force $= \frac{G m_1 m_2}{r^2}$

$= mg$ on surface of planet

spring force $= -kx$

friction force

static: $F \leq \mu_s N$

kinetic: $F = \mu_k N$

Next Lecture

- Engineering examples
- Read Friction handout
- Read Meriam 3/1 - 3/5